# RI Research Instruments view on Technology Transfer & Laboratory Collaboration

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# RI Research Instruments

research instruments

## Facts and figures

- Founded in 2009
- Employees 270

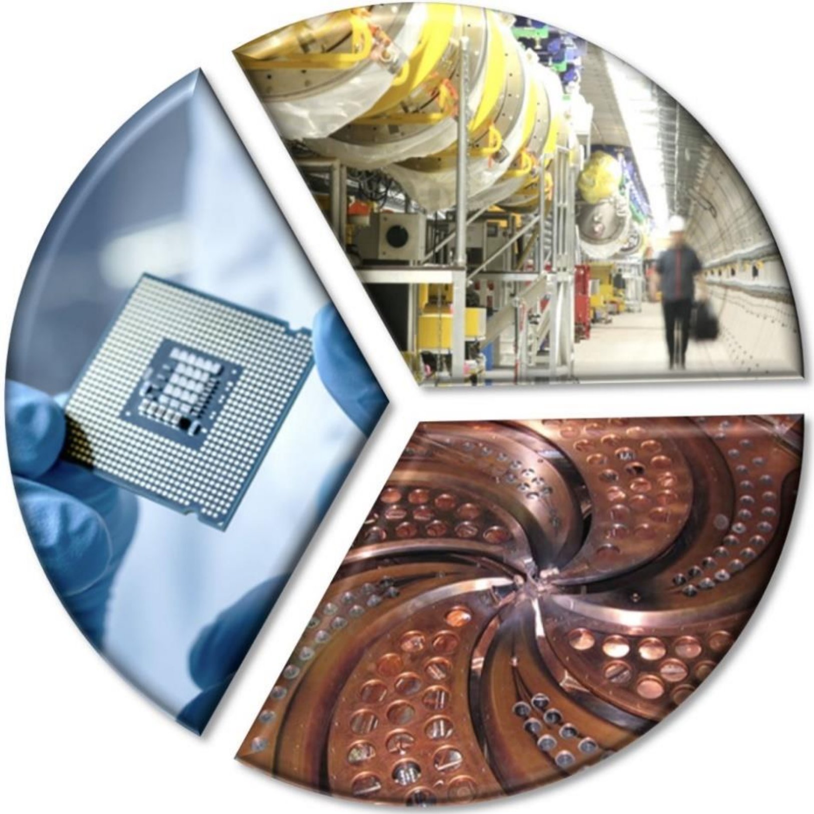
  ca. 110 physicists, engineers
  ca. 120 manufacturing specialists

- Annual revenue: 40 - 45 million EUR
- Established with the core team of ACCEL Instruments GmbH (1994-2009) and of INTERATOM/Siemens
- Management holds significant equity stake in the company which is majority owned by Bruker EST, Inc.

# Our customers

**Industry:**

- EUV tools
- Components for EUV lithography machines



**„Big Science“, worldwide institutes:**

- SRF cavities and accelerator modules
- Fusion equipment
- Normal conducting cavities, RFQ’s, linacs
- Photon instrumentation

**Medical & pharma:**

- Components for Varian proton therapy cylotrons
- Design of SRF accelerator for Mo99 production

# Our map of the world

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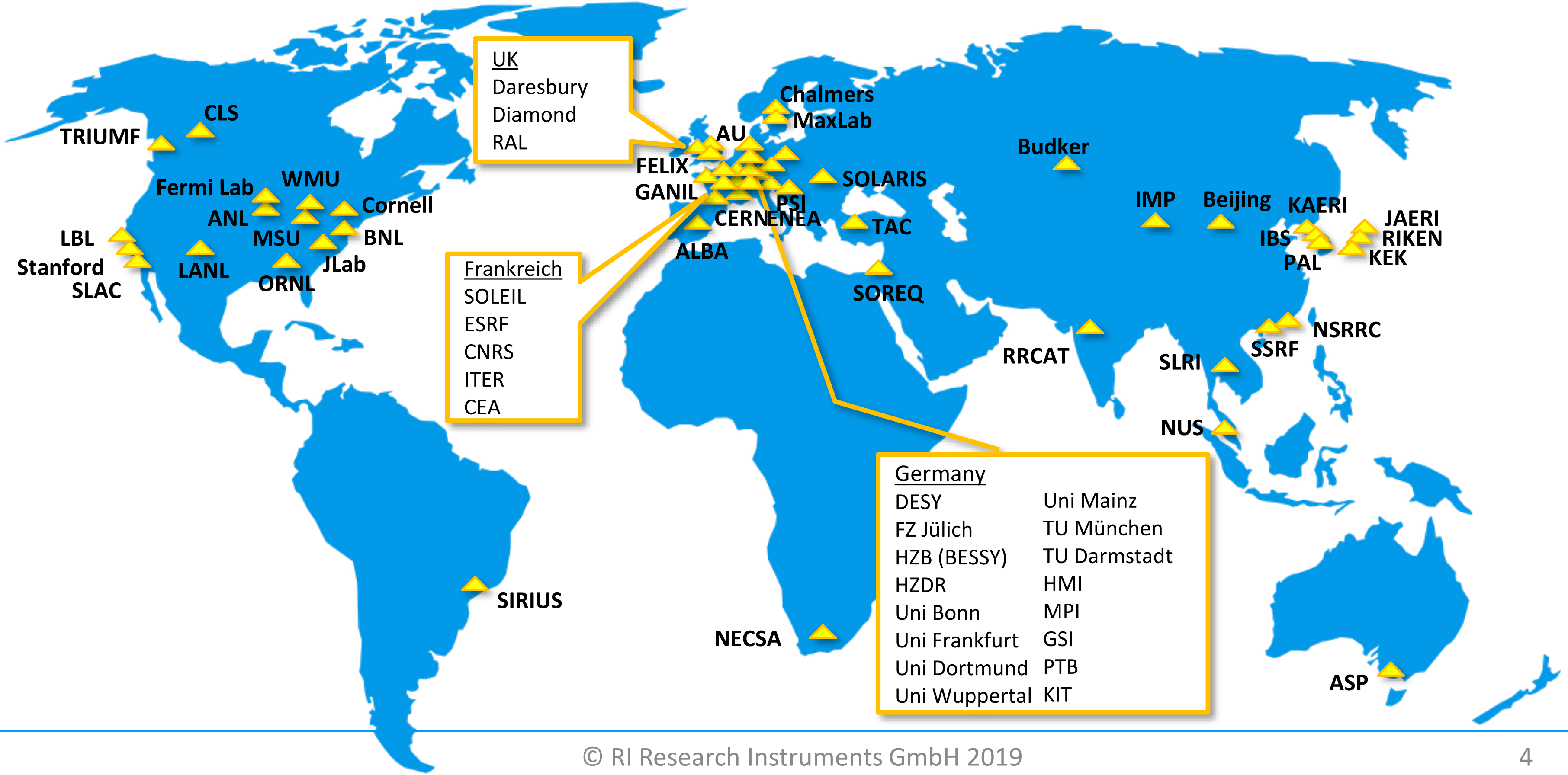

# Our site(s) in Bergisch Galdbach – 20 km away from the cathedral of Cologne

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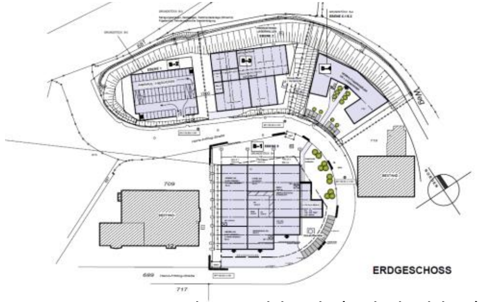
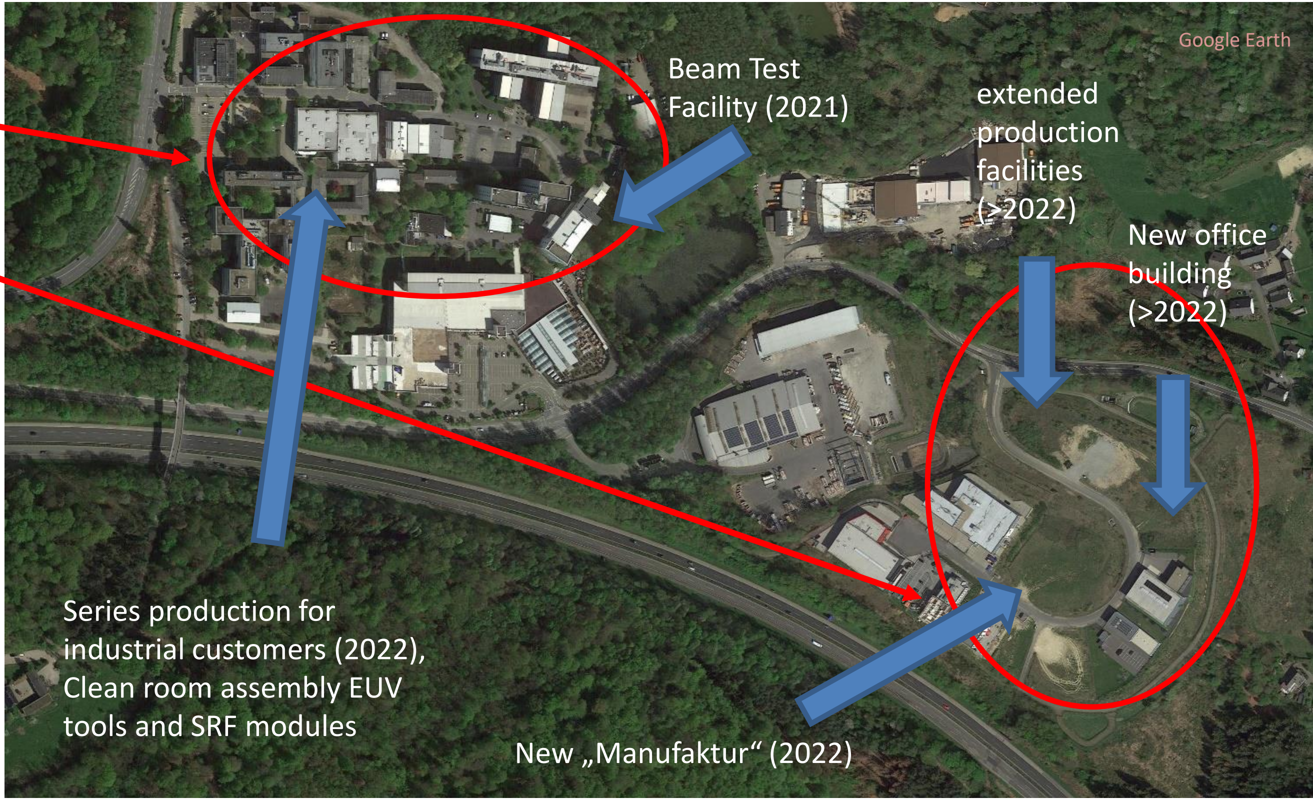
RI site at Technology Park

New RI site in Obereschbach

| RI space (sqm) | office | Production | sum |
|---|---|---|---|
| As of today | 1.900 | 7.400 | 9.300 |
| Additional in >2022 | 900 | 6.000 | 6.900 |
| Total in 2021 | 2.800 | 13.400 | 16.200 |




New campus in Obereschbach (in light blue)



# The RI manufactory

## A one-stop-shop on 6000 m$^2$

# The RI manufactory

## A one-stop-shop on 6000 m²

- Forming, milling and turning
- Certified welding and brazing
  - Electron beam welding
  - Vacuum and induction brazing
  - TIG welding
- Electro-chemical and physical surface preparation and coating

- Heat treatments
- Clean room assembly (ISO4, calls 10)
- State-of-the-art test facilities
  - RF measurements
  - Vacuum and cryogenics
  - Electromagnetic field measurements
  - Dimensional inspection, alignment and vibrational test

# Big science projects at RI (examples)

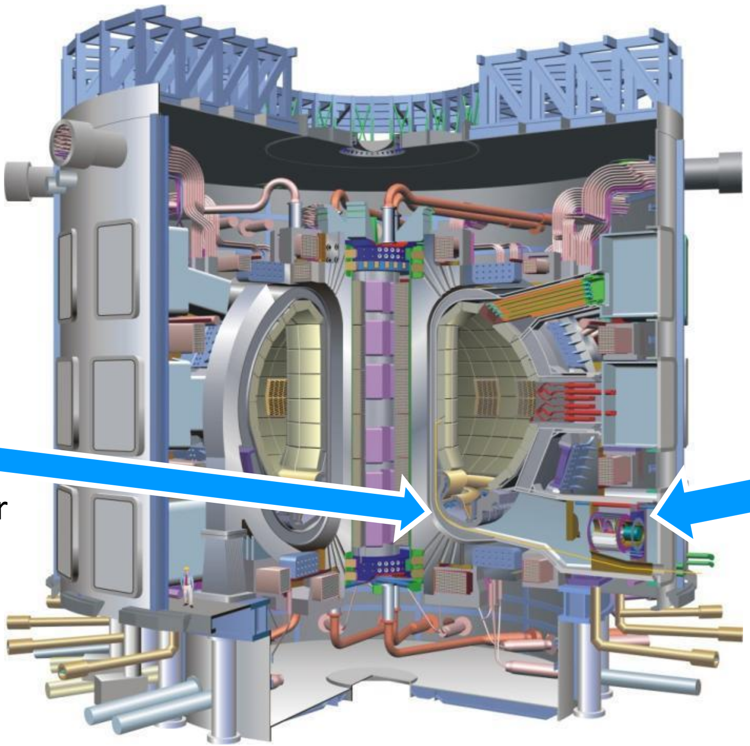
# ITER components by RI

**Grids for beam sources**

- Spider grids done, DNB grids ongoing
- MITICA grids under production since 2019
- tender of grids for ITER sources expected in 2022

**Inner vertical target (IVT)**

- Full scale prototype under production at RI
- tender of series expected in 2022



**IFMIF cryomodule assembly**

- Assembly at QST, Japan of an SRF module (8 HWR cavities) for proton acceleration
- Project should be finished in 2021

**Front end cryopump distribution system**

- Design and manufacturing of 8 cryogenic valve boxes
- contract received in June 2018

**Torus and vacuum vessel cryopump**

- Pre-production pump finished
- Now producing 8 pumps for torus and vacuum vessel

# Production of inner vertical target (IVT) divertor for ITER

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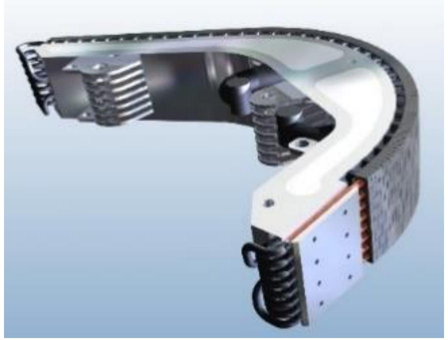
The divertor is a heavily heat loaded water cooled component (10-20 $MW/m^2$ peak) with surface temperature of about 2400 C

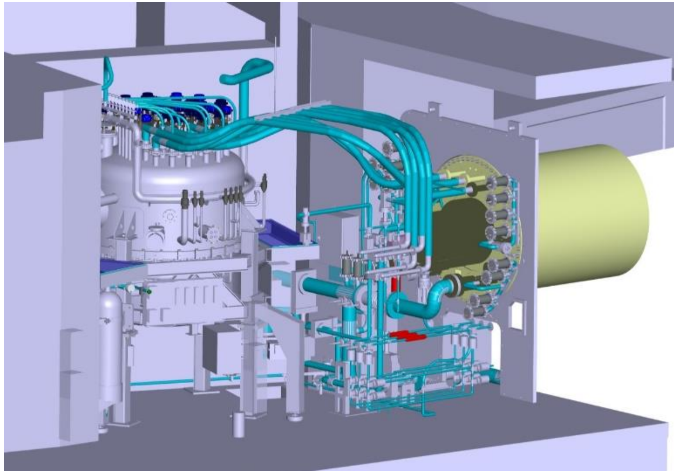
- Tungsten monoblocks brazed to CuCrZr-pipe
- Stainless steel caseate for support and water distribution

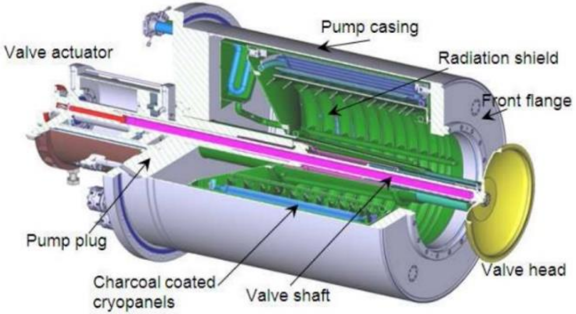
- Full scale IVT prototype production contract running (2018-2021)
- Series production (54 IVT) expected in 2022



# Design and production of valve boxes and cryopumps for ITER

- Design of valve boxes (cryogenic performance and thermal losses, radiation (1 MGy), earth quake)
- 8 valve boxes and 8 cryopumps under production at RI






- Valve box contains 23 cryogenic valves, operated between 4 K and 500 K
- Cryopumps (3 m length, 1,5 m diameter) contains big all metal valve for 30 000 cycles

# Normal conducting cavity production

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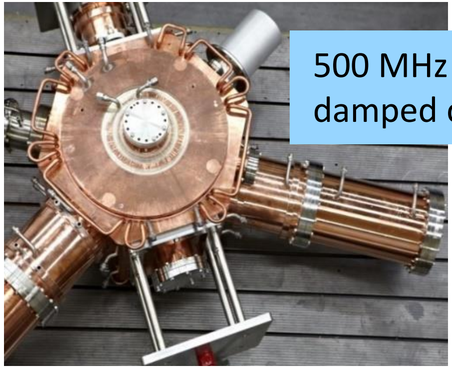
## Examples

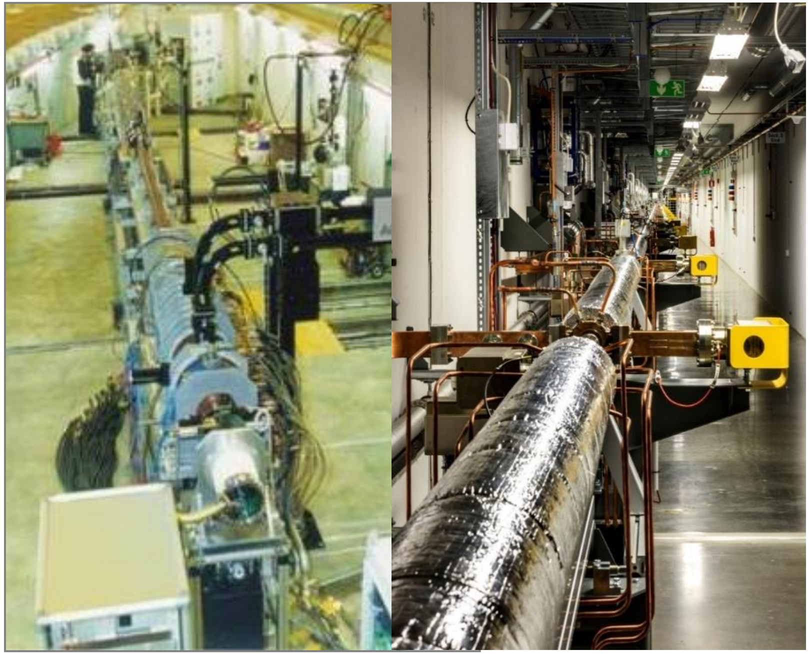
800 MHz (SNS), CCL structures

RFQ (Radio Frequency Quadrupole)



500 MHz HOM damped cavity

S-Band (2.998 GHz)



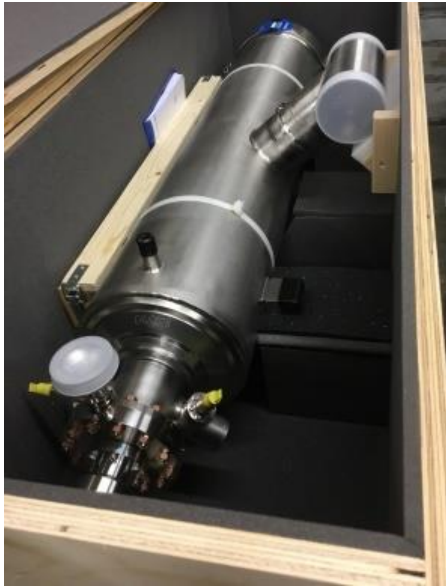
Turn key accelerators (up to 300 MeV)

# TESLA-type SRF cavity production

**420 cavities for European XFEL** project at DESY from 2010 to 2015

**378 cavities for LCLS-II** project at SLAC from 2015 to 2022

- Manufacturing of cavity, respecting the pressure vessel code
- Complete surface preparation and helium vessel welding
- Including N2 doping for LCLS-II



Cavities are shipped und vacuum ready for cold RF testing at customer

**Delivery rate: up to 4 cavities per week, first cavity 6 months after material receipt**

# Ongoing SRF cavity production at RI

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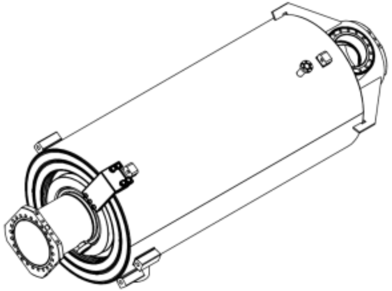
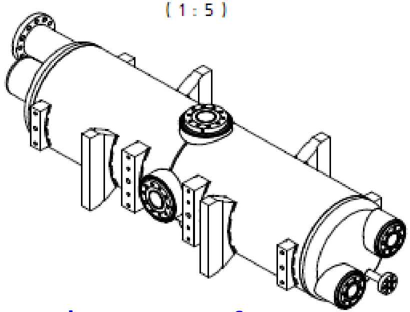
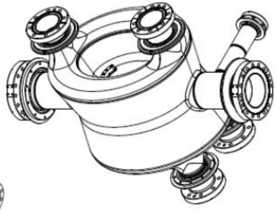


*88x ESS high beta for UKRI

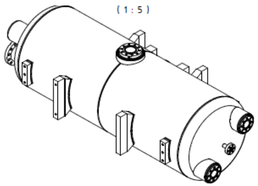



*52x HWR for IBS project

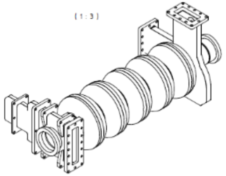
*30x PPU cavities for ORNL



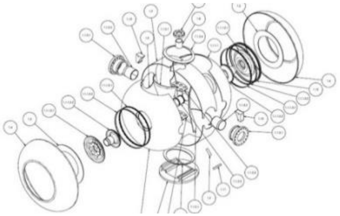
*11x crab cavities for CERN




**21x HWR for CEA/SARAF**



**16 x C75 cavities for JLAB**



*2 SSR2 spoke for IBS

In addition, various prototype cavities for international customers

**380 cavities** currently under production at RI

***Scope includes surface preparation (BCP/EP, HPR, clean room assembly)**

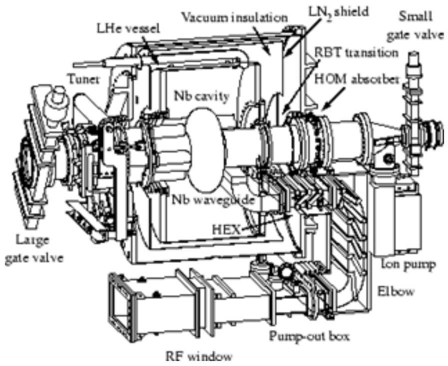
**Only mechanical manufacturing**

# Examples of Technology Transfer

# 500 MHz SRF turn key accelerator modules

## Technology transfer from Cornell University, USA

| | | |
|---|---|---|
| 2 SRF modules | for NSRRC, | Taiwan |
| 2 SRF modules | for CORNELL, | USA |
| 3 SRF modules | for CLS, | Canada |
| 4 SRF modules | for DLS, | Great Britain |
| 3 SRF modules | for SSRF, | PR China |
| 4 SRF modules | for PAL, | Korea |
| 2 SRF modules | for CNPEM | Brasil |




**Technology transfer startet 2000:**

- Upfront payment:
  - drawing set
  - manufacturing procedures
  - Consultation throughout the whole first 500 MHz SRF module production
- Fee (case by case) per module which includes:
  - License fo using Cornell 500 MHz SRF technology for manufacturing SRF modules for other Laboratories
  - Using 4 K vertical test facility at Cornell for cavity qualification testing prior module assembly

**Based on unburocratic and trustful collaboration between Cornell SRF experts and commercial staff and RI management and SRF project leaders and engineers.**

**20 SRF modules have been produced at RI so far**
**Terms of license agreement fits on 3 pages**

# Other examples of such technology transfer model at RI

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### 10 x SRF modules of the Rossendorf type (HZDR, Germany)

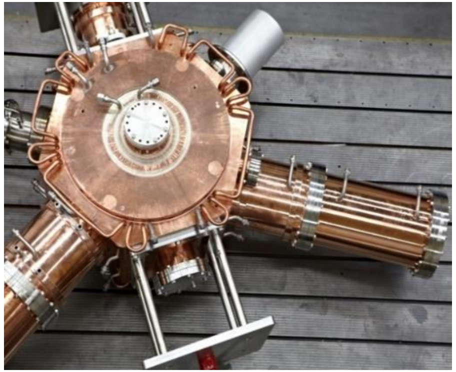
- STFC (2 modules)
- University of Mainz (2 modules)
- University of Ankara (2 modules)
- NCBJ, Poland (4 modules, after some redesign at RI)

### 58 x S-Band 5 m accelerator structures from DESY, Germany

- SLS (2 structures)
- DLS (2 structures)
- ASP (2 structures)
- PTB (1 structure)
- TLS (3 structures)
- University Nijmegen (1 structure)
- NSLS-II (BNL) (4 strcutures)
- Max-IV (40 structures)

### 23 x 500 MHz HOM damped cavities from HZB, Germany

- ALBA, Spain (7 cavities)
- HZB (8 cavities)
- DLS (3 cavities)
- LBNL (3 cavities)
- DELTA, Dortmund, Germany (1 cavity)
- PAL , Korea (1 cavity)

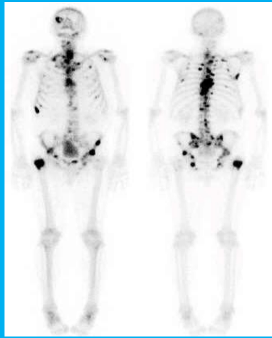


# The LightHouse project for Mo99 production

Customer:

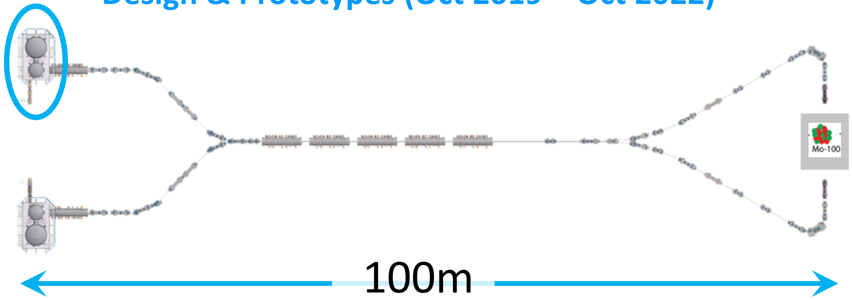
IRE is located in Belgium
one of the main supplier for Mo99

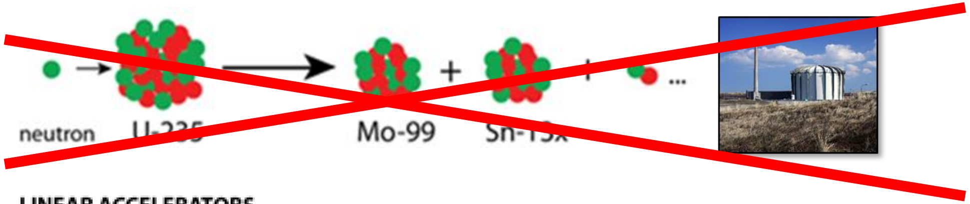
**worldwide ca. 40 Mio patients/year**



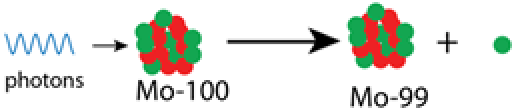
**Skeleton scan multiple metastases**

**RI contract:**
**Design & Prototypes (Oct 2019 – Oct 2022)**




LINEAR ACCELERATORS




LightHouse Isotopes

Scope of RI cover the complete accelerator (not the target)

- 75 MeV, 40 mA, 3 MW beam
- Beam source, beam dynamics
- Photoinjector, SRF modules
- 2 K helium plant, cryogenic distribution system)
- RF system based on solid state technology
- Diagnostics and control system
- Installation and commissioning

# LightHouse is based on Cornell ERL technology

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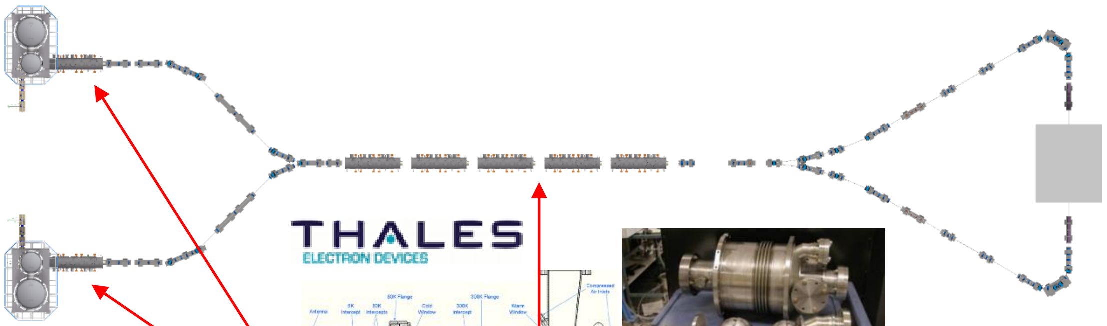
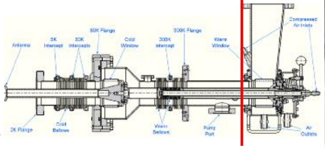
License for using Cornell technology is negotiated between our customer IRE and Cornell University



THALES ELECTRON DEVICES

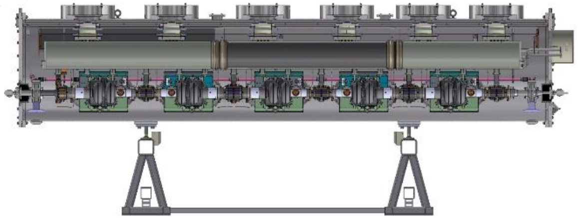


AMPHOS Member of the TRUMPF Group

COSYLAB

XP Power

CREATEC ENGINEERING SCIENCE



Cornell ERL SRF injector module

- A beam test facility based on the 400 kV Cornell photo injector is built up at RI
- 4 RF couplers for operation at 75 kW cw (1.3 GHz) are built at RI together with Thales
- One solid state 130 kW 1.3 GHz RF amplifier is under production at Cryoelectra

Cryoelectra RF Technology for Particle Accelerators

**Decison from IRE to built LightHouse is expected in 2022**

# LightHouse SRF accelerator
## Academic Cooperation Partners

| | | | |
|---|---|---|---|
| Cornell: | Photo Injector, SRF module | PTB: | Tests target |
| PSI: | Target | HZDR: | Tests target |
| HZB: | Laser, PC, RF-coupler tests | Univ. Namur: | Photocathodes |
| DESY: | SRF cavity tests, RF-couplers, ceramics | ETHZ: | SF6 replacement gases |
| Elettra: | beam loss monitors | CERN & | |
| MBI: | Laser | Univ Valencia: | Wake fields |

# Industry & Laboratory collaboration

# Fixed price contract versus time & material

Fixed price contract suited for:

- Well defined scope
- Demonstration that requested performance of deliverable has been reached before
- Development content of the project is low

Time & material suited for:

- Prototyping contract with high development content
- High risk projects due to requested but almost not reachable performance specification

Collaboration between industry and laboratory:

- Trust is key for success
- Understanding that price and schedule will change when scope changes
- Scope change should be acknowledged by laboratories, contracts should be written in a way that reasonable claims can be successful
- Otherwise industry might not be able to offer fixed price contracts

# Example of time and material contract

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**WGTS (Windowless gaseous tritium source)**
**for KATRIN (KArlsruhe TRItium Neutrino) experiment at KIT, Germany**

Weight 25 t, length 16 m, height 5 m, width 2 m

- Technologies: superconducting magnets, ultra high vacuum, cryogenics, alignment, welding, assembly, leak testing, QA, documentation
- 5 different cryogens used in WGTS: **Liquid neon**, **liquid argon**, **liquid nitrogen**, **liquid helium** and **gaseous helium**
- Delivered in September 2015, WGTS in full operation at KIT since 2017
- Assembly of the WGTS was successfully performed under time and material contract
  - 20% under budget and in schedule
  - Time and material encourages customer to find best and most practical solution for fixing problems which will occur during the execution of such complex projects